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[Title of the Invention] LIQUID CRYSTAL DISPLAY PANEL AND MANUFACTURING METHOD THEREOF

[Abstract]

[Object] Until a liquid crystal is filled into a panel, it typically takes more than 5 hours, and a temporal length of the process is a big neck in forming the panel.

[Solving Means] Considering that a primary neck of liquid crystal injection into a panel increases an injection resistance due to a panel distortion, in order to reduce the injection resistance, a gap length thereof is guaranteed, or a wider pipe portion is formed in the panel, so that a filling time can be reduced.

[Claims]

[Claim 1] A liquid crystal display panel comprising:

a pipe portion; and

a liquid crystal injecting port therein.

[Claim 2] The liquid crystal display panel according to Claim 1, wherein a Young's modulus of the pipe portion is larger than that of a member other than the pipe portion.

[Claim 3] The liquid crystal display panel according to Claim 1 or 2, wherein the pipe portion is made of glass or metal.

[Claim 4] The liquid crystal display panel according to

any one of Claims 1 to 3, wherein the Young's modulus of the pipe portion is larger than 5×10^{10} dyn/cm^2 and less than 1×10^{12} dyn/cm^2.

[Claim 5] The liquid crystal display panel according to any one of Claim 1, wherein parts in the liquid crystal display panel is removed to form the pipe portion.

[Claim 6] The liquid crystal display panel according to any one of Claims 1 to 4, wherein a pipe portion having a larger area is established at a portion where a gap length of the liquid crystal display panel is shortened.

[Claim 7] The liquid crystal display panel according to any one of Claims 1 to 5, wherein the liquid crystal injecting port is established at a peripheral potion of the liquid crystal display panel.

[Claim 8] The liquid crystal display panel according to Claim 5, wherein a dielectric layer of the liquid crystal display peripheral is removed to form the pipe portion.

[Claim 9] A liquid crystal display panel manufacturing method comprising:

forming a dielectric layer on a TFT of a lower substrate; and

removing a dielectric layer of a peripheral portion on the lower substrate

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a liquid crystal display panel and manufacturing method thereof capable of rapidly injecting a liquid crystal into a liquid crystal display panel.

[0002]

[Description of the Related Art]

Recently, a liquid crystal display panel market has been rapidly expanded as a display device. One example panel manufacturing process is a process of filling a liquid crystal into a panel prepared in advance in a vacuum state.

[0003]

[Problems to be Solved by the Invention]

However, until a liquid crystal is filled into a panel, it typically takes more than 5 hours, and a temporal length of the process is a big neck in forming the panel. In order to address this problem, filling a liquid crystal in a shorter time has been attempted by solving the equation of motion of a viscous fluid, and investigating a type and number of a liquid crystal injecting port (Chono Chuji Ekisho Vol. 3, No. 2, 107 (1999)). However, this calculation may not conform well to an actual liquid crystal injecting experiment, so that there is a need for a new liquid crystal injecting calculation method or overcoming

means.

[0004]

[Means for Solving the Problems]

The present invention involves a panel distortion, i.e., a change of a gap length when the inside of a panel a vacuum and a pressure is applied from the outside (Tamatini, etc., IEICE, Vol. J82-C-11 No.6 303). When the inside of the panel is a vacuum and the outside thereof is 1 atmosphere, considering that an elastic constant of a glass and a spacer in the panel, the distortion herein will be calculated that a gap length which is typically 5 µm is dented at most about 20% except a peripheral portion. An injection conductance is proportional to three order of the gap length, so that the dented herein causes a flow rate to be significantly reduced and thus the liquid crystal is difficult to inject. Therefore, a large gap length in the peripheral portion is used or a pipe portion with an artificially guaranteed gap length is formed to reduce a filling time.

[0005]

[Embodiments]

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

[0006]

In the prior art, a liquid crystal display panel typically has a construction as shown in Fig. 1. In a

peripheral portion of the panel, a vacuum sealing part is provided in a gap length of 5 μm, and a width of approximately several millimeters. A sealing material includes a glass chip, and at a portion around the sealing material a gap length is not so changed even when a pressure difference between the inside and the outside of the panel is several atmospheres. Further, inside the panel, spacers in a density of 10 to 200/mm^2 and in a diameter of 5 μm guarantees a gap. At this time, for a panel size, a length (a), a width (b), and a thickness (d), are determined as shown in Eq. 1.

[0007]

[Equation 1]

$a=b=20\,(cm)$

$d=0.07\,(cm)$

[0008]

A Young's modulus and a Poisson's ratio of a panel glass is as follows:

[0009]

[Equation 2]

$E=10.5\times10^{11}\,(dyn/cm^2)$

$\sigma=0.29$

[0010]

A Young's modulus of a spacer is as follows:

[0011]

[Equation 3]

$$E=0.7\times10^{11}(dyn/cm^2)$$

$$\sigma=0.35$$

[0012]

When the inside of the panel of an elastic body is a vacuum and a pressure of 1 atmosphere is applied from both sides, an elastic analysis is dented almost in a flat except for the peripheral portion as shown in fig. 2. A gap length around the peripheral portion is approximately 5 μm, but it is appreciated that the gap length is reduced about 20% even though the spacer exists inside the panel. Like this, it should be noted that liquid crystal is injected while expanding a narrow gap. In the conventional calculation, the experiment fact was not sufficiently realized since it was assumed that a value inside the gap length is uniform on an overall panel, like the peripheral portion, even when the inside of the panel is a vacuum.

[0013]

Hereinafter, analysis is progressed according to a formula of Chono, etc.

[0014]

Using a Leslie-Ericksen theory, a fluid equation of nematic liquid crystal is as follows.

[0015]

[Equation 4]

div v=0 (normal non-compressible continuity equation)

$$\rho\frac{\partial v}{\partial t}+v\cdot\frac{\partial v}{\partial x}=G-\nabla\cdot p+\nabla\cdot\tau$$ (Navier-Stokes' equation)

$$\tau=\alpha_1 A:nnnn+\alpha_2 nN+\alpha_3 Nn+\alpha_4 A+\alpha_5 nn\cdot A+\alpha_6 A\cdot nn$$ (shear stress)

[0016]

Here, v is a velocity vector, ρ is a fluid density, G is an external force, p is a pressure, τ is a shear stress tensor, and A, N, Ω are respectively,

[0017]

[Equation 5]

$$A=\frac{1}{2}((\nabla v)^T+\nabla v)$$ (modified velocity tensor)

$$N=\frac{\partial n}{\partial t}-\Omega\times n$$ (relative angular velocity vector of director and fluid)

$$\Omega=\mathrm{rot}\,v$$ (vorticity tensor)

[0018]

α1 to α6 are viscosity coefficients of Leslie. In the equation, the unknowns are a velocity vector v(x, y), a pressure p(x, y), and a director n(x, y), and since the number of equations are 3, it can be solved in principle. However, the viscous fluid velocity is significantly small, so that the following approximation can be employed. With

this approximation, the equation can be simplified. First, in the Navier-Stokes' equation, an inertia term of the fluid is negligible (Hele-Shaw approximation)

[0019]

[Equation 6]

$$\frac{\partial \tau_{zx}}{\partial z} = \frac{\partial P}{\partial x}$$

$$\frac{\partial \tau_{zy}}{\partial z} = \frac{\partial P}{\partial y}$$

[0020]

where $P = p+\rho gh$. Assume that the director n is already determined under a boundary condition of the panel, in the next approximation. A shear stress in this approximation is as follows:

[0021]

[Equation 7]

$$\tau_{zx} = f_1(z)\frac{\partial u(x,y,z)}{\partial z} + f_2(z)\frac{\partial v(x,y,z)}{\partial z}$$

$$\tau_{zy} = f_3(z)\frac{\partial u(x,y,z)}{\partial z} + f_4(z)\frac{\partial v(x,y,z)}{\partial z}$$

[0022]

where u and v are velocity components of the x direction and the y direction, respectively. In addition,

[0023]

[Equation 8]

$$2f_1(z) = (\eta_1 - \eta_3)\cos 2\theta(z) + \eta_1 + \eta_3$$

$$2f_2(z) = (\eta_1 - \eta_3)\sin 2\theta(z)$$

$$2f_3(z) = -(\eta_1 - \eta_3)\cos 2\theta(z) + \eta_1 + \eta_3$$

[0024]

where $2\eta_1 = \alpha_3 + \alpha_4 + \alpha_6$, $2\eta_3 = \alpha_4$, and θ is an angle between the director n and the x axis. Apply these to the Hele-Shaw approximation, and integrate in the z direction, then,

[0025]

[Equation 9]

$$u(x,y,z) = \frac{\partial P}{\partial x}\int_{-h}^{z}\frac{f_4(z')}{D(z')}z'dz' - \frac{\partial P}{\partial y}\int_{-h}^{z}\frac{f_2(z')}{D(z')}z'dz' + C_1(x,y)\int_{-h}^{z}\frac{f_4(z')}{D(z')}dz' - C_2(x,y)\int_{-h}^{z}\frac{f_2(z')}{D(z')}dz'$$

$$v(x,y,z) = -\frac{\partial P}{\partial x}\int_{-h}^{z}\frac{f_3(z')}{D(z')}z'dz' + \frac{\partial P}{\partial y}\int_{-h}^{z}\frac{f_1(z')}{D(z')}z'dz' - C_1(x,y)\int_{-h}^{z}\frac{f_3(z')}{D(z')}dz' + C_2(x,y)\int_{-h}^{z}\frac{f_1(z')}{D(z')}dz'$$

[0026]

Here,

[0027]

[Equation 10]

$$D(z) = f_1(z)f_4(z) - f_2(z)f_3(z)$$

[0028]

A velocity vector averaged in the z direction is as follows using h as a gap length:

[0029]

[Equation 11]

$$\vec{v}(x, y) = \frac{1}{2h}\int_{-h}^{h} v(x, y, z)\,dz$$

[0030]

so that, applying Equation 9,

[0031]

[Equation 12]

$$2h\bar{u}(x,y) = \frac{\partial P}{\partial x}S_4 - \frac{\partial P}{\partial y}S_2 - C_1(x, y)R_4 + C_2(x, y)R_2$$

$$2h\bar{v}(x,y) = -\frac{\partial P}{\partial x}S_3 + \frac{\partial P}{\partial y}S_1 - C_1(x, y)R_3 + C_2(x, y)R_1$$

[0032]

Here, C_1 (x, y) and C_2 (x, y) are integration integers, S_1 to S_4 are integers, and R_1 to R_4 are substituted values. Applying these to the Hele-Shaw approximate continuity equation, an elliptic derivative equation including diagonal terms on inputs can be finally obtained:

[0033]

[Equation 13]

$$G_1\frac{\partial^2 P}{\partial x^2} - (G_2 + G_3)\frac{\partial^2 P}{\partial x \partial y} + G_4\frac{\partial^2 P}{\partial y^2} = 0$$

[0034]

G_1, G_2, G_3, G_4 are coefficients of the derivative

equation. It should be noted that this equation is a derivative type so that it shows an input equation of a partial portion of the panel. In addition, when the director n is all parallel to the x-axis, $\theta = 0$ so that coefficients of the derivative equation is significantly simplified. Here,

[0035]

[Equation 14]

$$G_1 = -\frac{2h^3}{3\eta_1}$$

$$G_2 = G_3 = 0$$

$$G_4 = -\frac{2h^3}{3\eta_3}$$

[0036]

and, the derivative equation of the pressure P becomes an elliptical derivative equation in a type not including diagonal terms. Here, to solve the equation, a circuit estimate is performed as follows:

[0037]

[Equation 15]

$$P(x,y) \rightarrow V(x,y)$$

$$\frac{\partial P}{\partial x} \rightarrow j_x$$

$$\frac{\partial P}{\partial y} \rightarrow j_y$$

$$R_x \rightarrow \frac{\eta_1 \Delta x}{2h^3}$$

$$R_y \rightarrow \frac{\eta_3 \Delta y}{2h^3}$$

[0038]

Δx and Δy are differential unit displacement quantity. When this equation is changed into an equivalent circuit, it will be as show in Fig. 3. In other words, a current supplied to a resistance lattice is shown in a power supply voltage. Here, a potential V(x, y) of each node represents a pressure of each point of panel, and a current of each resistance represents a pressure gradient at this place (i.e., proportional to a flow rate (u, v). As the current grows larger, injection flow rate is large and thus a filling can be done in a short time. With a boundary condition appropriately given to the equivalent circuit, a solution can be easily obtained from the analysis of a circuit simulator.

[0039]

With respect to the circuit, it is apparent that a current strongly depends on a lattice resistance. Further, what determines the resistance value is a viscosity ratio of

the liquid crystal and a length of the gap. The viscosity of the liquid crystal is reduced about a half with an increase of temperature of 10 degrees around the room temperature, so that a resistance is reduced and an injection time is shortened when a temperature increases. However, in this method, there is a problem in that the remaining gas is easily produced.

[0040]

Therefore, a method of decreasing a resistance value can be appreciated when a temperature is lowered as possible. Focusing now on a gap length, R includes a term of three order of h, so that it is appreciated that R gives a biggest effect on the resistance value. As described above, when elasticity of the panel and the spacer is calculated, the panel is already dented sufficiently when a pressure difference between the inside and the outside is 1 atmosphere. When the gap length h of the panel central portion is estimated to be about 0.8 times of the peripheral portion. At this time, it is estimated that the resistance increases as much as specific times in which the panel is not distorted, and the injection rate of the liquid crystal is predominantly reduced.

[0041]

Meanwhile, in the panel peripheral portion, the gap length h is near a non-distorted state, so that it is

expected that a heat due to a relatively row resistance continues to emit. Therefore, a calculation value of a temporal change of the liquid crystal free surface is shown in Fig. 4 for a case where two injecting ports of the liquid crystal are arranged around the center of the panel, and a case where two injection ports are arranged at each of the right and left corners. Even when the liquid crystal is injected with an actual panel size of 339×196×0.005(mm), and a pressure difference between the inside and the outside of one atmosphere, for two injecting ports established around the center (length of 7 mm), the filling time exceeds 260 minutes, but when the right and left corner portions are established in the pipe portion of the liquid crystal, the injection time is reduced to about 100 minutes.

[0042]

Fig. 5 is a plan view and cross sectional view of a liquid crystal display panel having a pipe portion formed by removing a dielectric layer of the peripheral portion. Reference number 101 refers to a lower substrate, 102 a sealing portion, 103 a display portion, 104 a peripheral portion, 201 a lower substrate, 202 an upper substrate, 203 a source wiring, 204 a TFT, 205 a dielectric layer, 206 a pixel electrode, 207 a sealing portion, 208 a liquid crystal, and 209 refers to a pipe portion. In addition, an outer side of the sealing portion 102 almost corresponds to the

upper substrate 202. In addition, though not shown, the pixel electrode 206 is electrically connected a drain of the TFT, and overlaps over the source wiring or the TFT, so that an aperture ratio is increased. For a liquid crystal display panel forming an electrode by attaching a dielectric layer (typically, made of resin) having a thickness of 1 μm to 5 μm such as the TFT or a bus bar wiring as shown in Fig. 5, the dielectric layer of the panel peripheral portion was removed. In addition, the dielectric layer 205 is left on the display portion 103. As a result, the thickness of a cell of the panel peripheral port becomes thicker from 1 μm to 5 μm, and an injection time is reduced down to 80 minutes or less. This effect is most advantageous when the injecting port is arranged at right and left ends of the lower edge of the panel, but a sufficient effect is given even when the injecting port is arranged around the central portion of the lower edge of the panel due to a restriction such as the injecting device or products shape. In addition, in order to cause a cell thickness to be uniform, it is desirable that the dielectric layer below the sealing portion is not removed.

[0043]

In addition, even when there is a pressure difference between the inside and the outside by arranging a spacer made of glass or metal, which has a Young's modulus of

10^{12}(dyn/cm^2) larger than that of the spacer, within the panel as shown in Fig. 6, the pipe portion which is not dented is formed from the liquid crystal injecting port to the inside. With this arrangement, it is appreciated that an injection path is provided and the filling time is significantly reduced. With the panel having a size described above, when it is investigated for a case where the artificial path is provided and a case where the artificial path is not provided, the injection time of the liquid crystal will be 120 minute and 260 minute, which shows that the case where the artificial is provided is predominantly short. In addition, the Young's modulus of a material for use in the pipe portion is preferably 5×10^{10}(dyn/cm^2) to 10^{12} (dyn/cm^2). This is because that, when it is less than 5×10^{10}(dyn/cm^2), the gap between the panels cannot be maintained, and when it is larger than 10^{12} (dyn/cm^2), the wiring in the panel might be damaged. In addition, the more effect will be given with a small part of the gap length and thus many pipe portions established. As such, when a conductance of the path of the liquid crystal injection increases by increasing a gap length, an injection time can be significantly reduced.

[0044]

[Effect]

According to the present invention, with respect to a

panel distortion, which is a neck to liquid crystal injection, a pipe portion having a longer gap length is formed to thus realize a reduced filling time. It is advantageous in a liquid crystal display panel manufacturing process.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a schematic diagram of a typical liquid crystal display panel.

[Fig. 2]

Fig. 2 is a schematic diagram showing a panel distortion generated when there exists a pressure difference between the inside and the outside of the panel.

[Fig. 3]

Fig. 3 is an equivalent circuit diagram of an R lattice.

[Fig. 4]

Fig. 4A is a diagram showing a calculation value of a change of a liquid crystal free surface when an injecting port is established around a liquid crystal display panel center portion, and Fig. 4B is a diagram showing a calculation value of a change of a liquid crystal free surface when an injecting port is established around a liquid crystal display panel peripheral portion.

[Fig. 5]

Fig. 5A is a plan view of a liquid crystal display panel having a pipe portion formed by removing a dielectric layer of a peripheral portion, and Fig. 5B is a cross sectional view of a liquid crystal display panel having a pipe portion formed by removing a dielectric layer of a peripheral portion.

[Fig. 6]

Fig. 6 is a diagram showing an injection pipe portion established in a panel.

[Reference Numerals]

101: lower substrate
102: sealing portion
103: display portion
104: peripheral portion
201: lower substrate
202: upper substrate
203: source wiring
204: TFT
205: dielectric layer
206: pixel electrode
207: sealing portion
208: liquid crystal
209: pipe portion